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ABSTRACT—Use of woody vegetation as winter food by eastern cottontails *(Sylvilagus floridanus)* was investigated in a southeastern Minnesota farmstead shelterbelt. Cottontails browsed on 11 species but exhibited a clear preference only for gooseberry (*Ribes* spp). When snow covered herbaceous vegetation during late winter, cottontails relied more heavily on high fiber, lower protein woody browse. Shelterbelt management that allows invasion of gooseberry and blackcap raspberry (*Rubus occidentalis*) provides winter food for cottontails and may reduce damage to planted trees.

In northern latitudes, the diet of the eastern cottontail (*Sylvilagus floridanus*) consists primarily of woody vegetation during winter when snow covers herbaceous food items for long periods (McCabe, 1945). In the central United States, wooded habitat types in agricultural regions comprise less than 3 percent of the total land acreage. Although a substantial fraction of these wooded areas is represented by farmstead shelterbelts (Griffith, 1976), little information exists regarding browse selection by cottontails in shelterbelts.

Objectives of the present study were to: (1) assess browse use by cottontails in a mature farmstead shelterbelt, (2) identify strategies of foraging employed by cottontails, and (3) discuss these findings in terms of shelterbelt management.

Quantification of browse use

Browse use by cottontails was studied from November 1980 to April, 1981 in a 0.70-ha, L-shaped shelterbelt at the Rosemount Agricultural Experiment Station, Dakota County, Minnesota. This shelterbelt was selected for study because it contained a high number of woody plant species (n = 20) and was representative of mature shelterbelts in intensively-farmed regions of the upper Midwest in both age and plant composition. Common planted species included Colorado blue spruce (*picea pungens*), jack pine (*Pinus banksiana*), red pine (*pinus resinosa*), northern white cedar (*Thuja occidentalis*), eastern cottonwood (*Populus deltoides*), and American elm (*Ulmus americana*). Common colonizing species were blackcap raspberry (*Rubus occidentalis*), caragana (*Caragana arborescens*), red-berried elder (*Sambucus pubens*), green ash (*Fraxinus pennsylvanica*), and tartarian honeysuckle (*Lonicera tatarica*). The outter edge of the shelterbelt was bordered by cultivated fields, and the inner edge adjoined a farmstead lawn. During winter, cottontails did not use areas surrounding the shelterbelt (Swihart, 1981). A detailed description of the shelterbelt is provided elsewher (Yahner, 1980).

Nineteen randomly-located, 1-m transects were permanently established at right angles to the long axis of the shelterbelt in November 1980. Two vertical strata were distinguished in each transect: less than 0.5 m and 0.5-1.0 m above ground level. Two to three samples of twigs were collected during November 1980 for each of the 12 most common species; each sample contained twigs from two to five randomly-selected plants in the shelterbelt. If a species occurred infrequently in the shelterbelt, twig samples were collected from comparable areas within a 2-km radius of the study site. In the present study, twigs were defined as those parts of a branch rooted in a transect, greater than 7.5 cm in length, and less than 8 mm in diameter (after Telfer, 1972; Grigal and Moody, 1980). A diameter of 8 mm was used because preliminary censuses of one to two year-old clippings indicated that the largest size class browsed by cottontails was 8 mm.

Following collection, the diameter of each air-dry twig was measured, and weights of oven-dry twigs were recorded. From these measurements, least-squares regression equations were derived for each species and used in estimating available twig biomass.

Counts of browsed and unbrowsed twigs within each stratum were recorded for each transect in April 1981. Diameter at the point of browsing (dpb) was measured from twigs pruned by cottontails. Upon determining mean dpb, each twig sample was subdivided into two diameter classes, Diameter class 1 represented twigs with diameters less than the mean dpb + 2 standard errors for a given species, and diameter class 2 represented twigs larger than this cutoff but less than 8 mm by definition. Thus, twigs were excluded from diameter class 1 if they exceeded the upper bound of the 95 percent confidence interval for the mean dpb. This categorization uas used to separate twig sizes actually browsed by cottontails (Pease et al., 1979) from unbrowsed but available sizes. All twigs less than 8 mm in diameter were presumably available as potential browse (see above). Each subdivided sample was ground in a Wiley mill and chemically analyzed. Concentrations of P, K, Ca, Mg, and Na were determined using ICP emission spectroscopy. Crude protein (6.25 x N) was analyzed using the Kjeldahl procedure. In addition, acid detergent fiber (ADF) content was determined using standard procedures (Goering and Van Soest, 1970).

To investigate foraging strategies, fecal pellets of cottontails were collected from December 1980 to April 1981 in the shelterbelt and at two other wooded sites within 0.75 km of the study site. Diameters of air-dry pellets were measured, and weights of oven-dry pellets were recorded. Pellet samples were separated according to date and location of collection and were chemically analyzed as described above.

Tests of significance were conducted at the 0.01 level unless otherwise stated.

Browse use and preference ratings

Preference ratings were defined as the ratio of twig biomass browsed and twig biomass available. In each transect, ratings were calculated for each species if at least 2 percent of that

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species' total sampled biomass occurred in the transect. Averages of these transect ratings wer calculated for each species, and differences among means were tested using analysis of variance with GT2 *a posteriori* comparisons (Sokal and Rohlf, 1981). Preference values greater than 1 characterize species that are browsed more intensively than expected based on their availability (petrides, 1975).

Because the majority of browsed twigs (ii percent) occurred in the lower stratum, only this layer was used in calculating relative preference ratings. A rank ordering of average preference values (Table 1) indicated that an uncommon species, gooseberry (*Ribes* spp.), was most highly preferred, followed in descending order by common chokecherry (*Prunus virginiana*), American elm, and blackcap raspberry. The latter two species comprised 77 percent of the total biomass consumed; therefore, blackcap raspberry and American elm were the principal woody foods (petrides, 1975) of cottontails in this study. Conversely, conifers were avoided (Table 1). These results concur with findings presented by Swihart and Yahner (1983); namely, cottontails prefer members of the Rosaceae and Ulmaceae families and generally avoid conifers.

Although rank ordering preference ratings suggested that cottontails exhibited dietary preferences during winter, analysis of variance revealed that only gooseberry was browsed preferentially (Table 1). Mean preference values of the remaining species were not significantly different from one another (0.05 level of significance). Nudds (1980) proposed that the correlation between use and availability of browse species represented a more conservative test of preferences than the ratio of these two values. In general, a positive correlation between use and availability characterizes a generalized feeding strategy. In the present study, a significant positive correlation existed ($r = 0.88$). Hence, we conclude that cottontails did not exhibit strong dietary preferences in the shelterbelt.

Rank correlations between preference by biomass (Table 1) and mean nutrient content (Table 2) of each browse species revealed no significant relationships at the 0.05 level. This is not surprising, because all preference values except gooseberry were statistically indistinguishable (Table 1).

Table 1. Availability, use, and preferences of woody plants by cottontails in a southeastern Minnesota farmstead shelterbelt, winter 1980-81. Biomass values are for stratum 1 only. Preference values followed by the same letter are not different from one another at the 0.05 level of significance.

Species	TOTAL Twig Biomass Available (kg/ha)	TOTAL Twig Biomass Browsed (kg/ha)	Average Preference Rating
Gooseberry	0.57	0.47	18.86 a
Common chokecherry	2.62	1.35	2.64 b
American elm	7.26	3.32	2.43 b
Blackcap raspberry	32.83	9.20	1.55 b
Green ash	9.05	0.86	0.66 b
Tartarian honeysuckle	11.08	0.95	0.57 b
Caragana	0.77	0.03	0.12 b
Virginia creeper	2.18	0.04	0.06 b
Colorado blue spruce	9.17	0.05	0.05 b
Red-berried elder	2.83	0.04	0.03 b
Eastern white pine	9.32	0.00	0.00 -
Northern white cedar	0.80	0.00	0.00 -

In summary, cottontails displayed generalized food habits with a strong preference only for gooseberry. This does not imply that cottontails were unselective, because selectivity may exist in generalist feeders (Clark, 1982). For instance, if cottontails require a mixed diet (i.e., dietary requirements could not be satisfied by a single browse species), specific combinations and proportions of species may be required to fulfill an individual's dietary needs (Rapport, 1981). Clearly, a generalist feeder of this type should be selective, but preference values will not reflect such selectivity (nor will they be indicative of true preferences). To accurately assess selectivity, meal composition should be examined (Clark, 1982).

Foraging strategies

Fiber content ($r = 0.93$) and crude protein ($r = -0.78$) of fecal pellets were significantly correlated with date of collection, indicating that higher fiber, lower protein foods became more prominent in the diet as winter progressed. Snow depth in the shelterbelt averaged 2 cm in December and January. During this period of sparse snow accumulation, dry herbaceous vegetation (54 percent ground coverage) was available to cottontails and presumably comprised a substantial portion of their diet (Korschgen, 1980). However, snow depth in February averaged 17 cm, forcing cottontails to rely more on a diet of relatively high fiber, low protein woody vegetation. Fiber content of fecal pellets also was significantly correlated with greater pellet weights ($r = 0.91$); hence, monitoring changes in pellet weights over time may provide a useful index to seasonal trends in dietary fiber content for *S. floridanus*.

Correlation analyses were conducted on mineral content of fecal pellets and date of pellet collection to assess temporal changes in mineral intake. Concentrations of Ca in pellets displayed a significant ($r = 0.81$) increase as winter progressed, whereas the Mg content of pellets declined ($r = -0.50$), although not significantly. Because the demand for Ca is high among pregnant females during the latter stages of winter and large quantities of Mg in the diet inhibit Ca retentin (Chicco et al., 1973), increasing Ca intake while simultaneously decreasing Mg intake may be advantageous for pregnant females.

Differences in mean nutrient content of diameter class 1 versus diameter class 2 twigs existed for at least some nutrients for all species (Table 2). Smaller diameter twigs (class 1) of a species provided relatively greater nutritional benefits than did larger twigs (class 2). Cottontails could obtain an equivalent quantity of nutrients and ingest less material by foraging on small twigs rather than large twigs. Grigal and Moody (1980) drew similar conclusions for twigs of beaked hazel (*Corylus cornuta*), serviceberry (*Amelanchier* spp.), and Sitka alder (*Alnus sinuata*) in northeastern Minnesota.

Management implications

In many intensively-cultivated regions of the central United States, farmstead shelterbelts serve as important habitat for cottontails, especially in winter (Swihart, 1981). However, landowners wishing to maintain a cottontail population in winter are faced with the problem of browse damage to trees planted in shelterbelts. We hypothesize that cessation of mowing between rows once trees are established will allow invasion by species that are preferred and/or used extensively as winter food by cottontails; i.e., *Ribes* and *Rubus*. These invading species will not harm established trees, and they may serve as "buffers" to prevent browsing damage to planted trees. Further research is needed to test this hypothesis.

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Species	Size Class	ADF	Crude Protein	P	K	Ca	Mg	Na
Gooseberry	1	58.1	7.81	0.19*	0.78*	1.00	0.13**	0.04
	2	61.6	5.69	0.15	0.53	0.76	0.09	0.06
Common chokecherry	1	46.7*	8.31	0.18	0.46	1.00*	0.14*	0.07
	2	55.6	7.06	0.14	0.37	0.65	0.10	0.04
American elm	1	53.5	8.19*	0.15	0.43*	1.42**	0.17**	0.07**
	2	56.7	6.56	0.14	0.29	0.82	0.12	0.04
Blackcap raspberry	1	49.7	8.12	0.12	0.47**	0.87	0.34**	0.13
	2	50.0	6.75	0.12	0.34	0.72	0.26	0.09
Tartarian honeysuckle	1	47.9*	7.88	0.13**	1.18	0.61**	0.21**	0.06*
	2	53.8	5.94	0.10	0.97	0.41	0.16	0.04
Caragana	1	51.6	20.75	0.16	0.64*	0.78*	0.15*	0.06**
	2	49.1	18.12	0.14	0.56	0.67	0.12	0.04
Virginia creeper	1	43.7	14.00	0.24**	1.01	1.19	0.16	0.05
	2	47.8	11.62	0.20	0.95	1.29	0.15	0.05
Colorado blue spruce	1	36.5**	7.44**	0.14**	0.66**	0.99	0.12**	0.08
	2	43.8	6.69	0.12	0.52	1.04	0.11	0.08
Red-berried elder	1	45.7	12.19*	0.20	1.14*	0.64	0.21	0.05*
	2	50.1	10.56	0.19	0.92	0.59	0.20	0.03

Table 2. Mean nutrient content (%of dry weight) and differences between browsed (size class 1) and unbrowsed (size class 2) twigs. One asterisk denotes differences significant at the 0.05 level, whereas 2 asterisks denote differences at the 0.01 level. Green ash samples were inadvertently destroyed prior to chemical analysis.

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